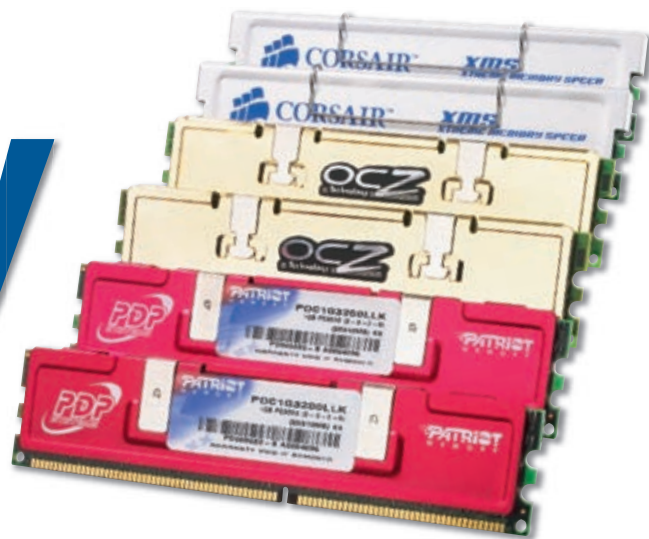




Memory



The amount and type of memory in a PC makes all the difference to its performance. We explain how to choose the best RAM for your system and how overclocking can increase your PC's speed

No matter how fast your processor is, unless you have enough RAM you'll probably spend ages waiting for the irritating Windows hourglass to disappear every time you load an application or start a level of Half-Life 2. A memory upgrade will allow your PC to run at its full potential and could also open the door to the world of overclocking, where you can get extra performance for free.

This guide explains all your options. You'll find out what RAM is best suited to your PC, whether you want to upgrade, build a new PC or perhaps try overclocking your system. We test 17 of the more commonly available RAM modules on the market, where possible sold as 1GB matched pairs.



CHOOSING... MEMORY

There are so many different types of RAM, visiting an online retailer for the first time can make you feel overwhelmed with choice. But fear not, it's not as complicated as it looks.

All you have to do is make two decisions. First of all, you need to determine whether your PC supports double-data rate (DDR) or DDR2 RAM. If the processor is an Athlon XP, Sempron or Athlon 64, it will need DDR. If it's a Pentium 4, it could be DDR or DDR2. The table below shows the most common processors and chipsets, and which type of memory they support.

For other chips, or just to be doubly sure, you should check your motherboard manual for the kind of memory required. If you didn't get one, you should be able to download a copy from the manufacturer's website. Your motherboard manual will also tell you if it supports memory in dual-channel mode. If it does, fitting memory modules in matched pairs will give you slightly better performance, which is the reason we've chosen to review pairs of 512MB DIMMs here.

CLOCK WISE

Once you've established whether you need DDR or DDR2 RAM, you need to decide if you're ever going to try overclocking your PC. If you're not, choosing

the right speed of memory is easy. If you need DDR then you should buy PC3200 modules, also known as 400MHz modules. Such modules are designed for a maximum memory bus speed of 200MHz, but they deliver data twice per clock cycle, giving an effective speed of 400MHz. The PC3200 rating relates to the bandwidth of the modules. They can provide 3.2GB/s of bandwidth to the processor, while a matched pair working in dual-channel mode will provide 6.4GB/s.

Unless you overclock, your DDR memory bus will never exceed 200MHz, so PC3200 modules are perfectly adequate. The only other specification you may wish to consider is the memory's latency timings, which tell you how quickly the module can access the data stored within it. There are about 10 different latency timings, but most manufacturers just tell you the first four, which are usually quoted in series, such as 3-4-4-8. In theory, the lower the numbers, the faster the RAM will perform. However, as you can see in the graphs on the opposite page, the difference is very subtle.

If your PC needs DDR2, unless you overclock, your memory bus will go no faster than 266MHz. Consequently, you need PC2-4200 RAM, which delivers data at 533MHz and provides 4.2GB/s bandwidth. Two modules provide 8.4GB/s in dual-channel mode.

OVER TIME

If you want to squeeze some extra performance out of your PC then you need overclocking RAM. Overclocking RAM is designed to run much faster than standard RAM, so you can overclock your processor and motherboard freely without fear of the memory stopping working.

Not all CPUs and motherboards are designed to be overclocked, though, and your PC will need a good-quality processor and sufficient cooling for success. Buying overclocking RAM will not necessarily allow you to overclock your PC. That said, without overclocking RAM you'll be a lot less likely to achieve any significant increase in speed before your PC becomes unstable.

The basic technique of overclocking is to raise the frontside bus (FSB) of the processor from its default, which is usually 200MHz. This raises the speed of the processor and memory bus in proportion. For example, a 2.8GHz Pentium 4 has a 200MHz FSB and a clock multiplier of 14 (14x200=2,800). So if you raise the FSB to 240MHz the processor will run at 3.36GHz (14x240=3,360) but your memory bus will also be going at 240MHz, which means you'll need memory rated at PC3840

(remember PC3200 is good up to 200MHz). As you push your system harder, you may have to increase the voltage passing through the processor and motherboard. Just be careful and increase the voltage in small steps; too much voltage can be worse than not enough, causing the processor to overheat and shut down.

If your motherboard has been designed with overclocking in mind, you should be able to find the FSB frequency and processor voltage settings in the BIOS. If in doubt, overclock gently, raising the FSB in 5-10MHz jumps, booting into Windows and running some applications before overclocking any further. Read the motherboard reviews we publish every month to see which are best for overclocking.

Just one final word of warning: overclocking your PC will invalidate its warranty. Be gentle and don't try to push too far, as components can be damaged by too much overclocking or voltage.

MEMORY JOGGERS

Choosing the right overclocking RAM is a bit more complicated than standard RAM as there are no standard rated speeds. For example, the four overclocking DDR modules we tested are rated from PC4000 (250MHz bus, 500MHz effective) to

IN THIS REVIEW

DDR RAM

Buffalo DD400-512MAx2KIT
Corsair Value Select VS1GBKIT400C3
Crucial CT2KIT6464Z40B
Elixir 512MB x2
Kingston KVR400X64C3AK2/1G
MOT 512MB x2
OCZ OCZ4001024WV3DC-K
Patriot PDC1G3200LLK

DDR2 RAM

Buffalo D2U533B-1G
Corsair Value Select VS1GBKIT667D2
MOT 512MB x2
OCZ OCZ25331024ELDCGE-K

OVERCLOCKING DDR RAM

Corsair TWINX1024-4400C25PT
Crucial BL2KIT6464L50S
OCZ 5001024ELDCGER2-K

OVERCLOCKING DDR2 RAM

Corsair TWIN2X1024-8000UL
Kingston KHX5400D2K2/1G

PROCESSOR	CHIPSET	SUPPORTED RAM
Athlon XP/Sempron	All	DDR
Athlon 64	All	DDR
Pentium 4/Celeron	865 or 875	DDR
	915	DDR or DDR2
	925	DDR2
	945 or 955	DDR2
	nForce4 Intel	DDR2



PC4400 (275MHz bus, 550MHz effective), making them faster than the PC3200 of standard DDR. If your processor and motherboard are up to it, you could raise the FSB of your processor from 200MHz to 275MHz, giving your PC a huge performance boost. Overclocking-friendly DDR2 can be rated at anything from PC2-5400 to PC2-8000. Assuming your Pentium 4 and motherboard are willing to play along, you can raise the FSB of your processor from 200MHz to over 300MHz with the PC2-8000 memory. As with non-overclocking RAM, the lower the latency timings, the quicker the RAM.

AND FINALLY...

Mixing different modules of memory in a motherboard occasionally leads to incompatibilities. You should buy enough memory to replace your existing memory. This is why we've reviewed 1GB pairs of DIMMs. If your PC has 512MB of RAM and you buy a further 512MB, you're in a bad situation if your new RAM proves incompatible with your old. If you buy 1GB, the worst-case scenario is that you'll have to sell your old memory and settle for a 1GB computer. If all goes well, you'll have a generous 1.5GB memory for Windows to play with.

HOW WE TESTED

When evaluating random access memory (RAM), you need to know how reliable and how fast it really is. To test the four different varieties of RAM, we built two PCs: an Athlon 64 system to test all the DDR and a Pentium 4 to test the DDR2. The Athlon 64 3000+, which runs at 1.8GHz, was plugged into an Asus A8N-SLI Premium motherboard, which is based on the nForce4 SLI chipset. The 2.8GHz Pentium 4 was placed in an Asus P5WD2 Premium motherboard, which is based on the 955X chipset.

We chose these particular processors and motherboards because we know they overclock extremely well. Obviously, this wasn't important for testing the non-overclocking RAM. However, by using the same PCs to test the overclocking RAM you can easily see the performance benefit gained from overclocking. We ran the video-encoding and image-editing segments of our benchmarks plus Doom 3 at 1,024x768 with 4x anti-aliasing on all sets of RAM.

Not all processors are created equal, of course, and so not all Athlon 64 3000+ and 2.8GHz Pentium 4s will overclock this well. Our processors were hand-selected to test the overclocking RAM to its limits. Consequently, the benchmark results below show a best-case scenario of what performance can potentially be achieved by overclocking, and not necessarily what you will be able to achieve. But who knows? Maybe you will be able to overclock further than us. Generally speaking, the lower clock frequency processors will overclock further than the faster processors, which is why we used a 2.8GHz Pentium 4. For Athlon 64s it's a little different; in most motherboards, you can lower the clock multiplier. This means you could, for example, lower the multiplier on an Athlon 64 3800+ and raise the frontside bus (FSB) speed. So instead of it running at 2.4GHz on a 200MHz bus with a multiplier of 12, you might get it running at 2.475GHz on a 275MHz bus using a multiplier of 9 and PC4400 RAM, improving the processor and memory performance in the process.

BENCHMARKS

Fast DDR2

DDR2

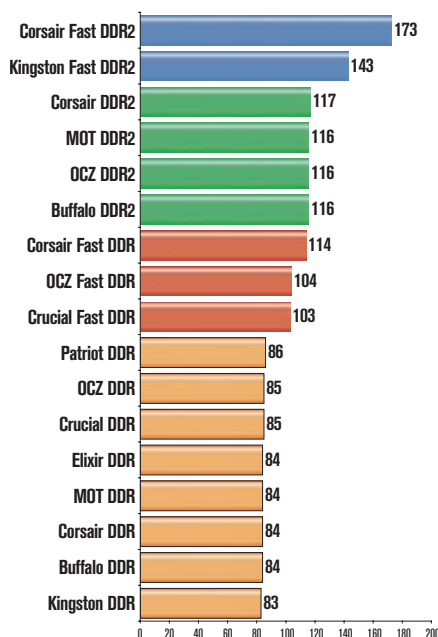
Fast DDR

DDR

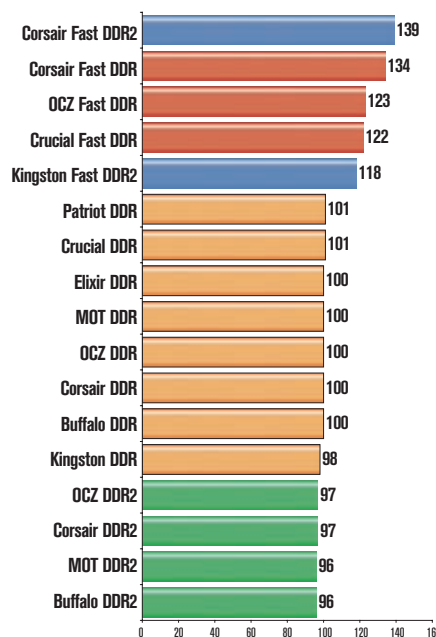
2D Performance

Shopper application tests

Image-Editing Test



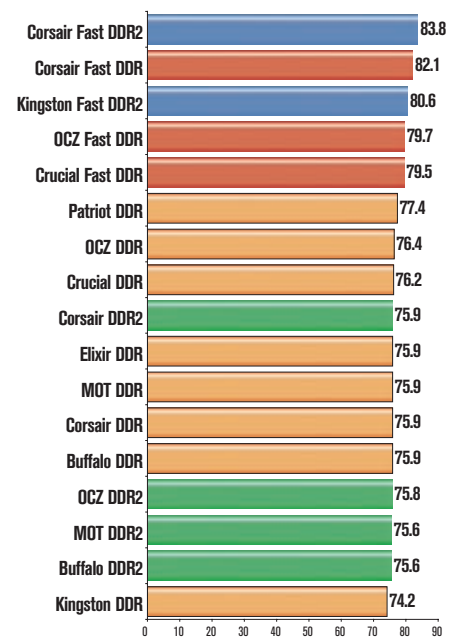
Video-Encoding Test



3D

Doom 3

Doom 3 (fps)



SETTINGS We run our application tests at 1,024x768 resolution and in 32-bit colour

WEB www.computershopper.co.uk

Computer Shopper's 2D benchmarks are designed to show how PCs stand up to the toughest tasks Windows can throw at them. Today's PCs have no problem running office applications such as Word

and Excel, so we chose to focus our tests on areas where you could experience difficulties. Our image-editing test simulates photo enhancement using Paint Shop Pro, culminating with the memory-intensive composition of a panorama from a set of digital snaps. Encoding a video to MPEG2 format is a processor-intensive task, and one that anyone interested in transferring home videos to DVD must tackle. We compiled the tests with the help of our sister title for performance computing, *Custom PC*.



SETTINGS 1,024x768 resolution, high quality, 4x AA
WEB www.doom3.com

We run a timed demo in Doom 3 to test whether the RAM provided the memory bandwidth needed to play cutting-edge 3D games with ease. A good score here means that it should cope with any graphically intense 3D game.



DDR



MANUFACTURER	BUFFALO	CORSAIR	CRUCIAL	ELIXIR	KINGSTON
Model	DD400-512MAx2KIT	Value Select VS1GBKIT400C3	CT2KIT6464Z40B	512MB x2	KVR400X64C3AK2/1G
Type	DDR	DDR	DDR	DDR	DDR
Rating	★★★★	★★★★★	★★★	★★★★	★★
Module size	512MB	512MB	512MB	512MB	512MB
Rated speed	400MHz	400MHz	400MHz	400MHz	400MHz
Rated bandwidth	PC3200	PC3200	PC3200	PC3200	PC3200
Latencies at this speed	3-4-4-8	3-4-4-8	3-3-3-8	3-4-4-8	3-3-3-8
Maximum speed in tests	Would not overclock	Would not overclock	440MHz	Would not overclock	Would not overclock
Maximum processor speed in tests	Would not overclock	Would not overclock	1.98GHz	Would not overclock	Would not overclock
Heatspreader	No	No	No	No	No
Price for pair (inc VAT)	£75	£72	£89	£66	£74
Supplier	www.maplecomputercomponents.co.uk	www.scan.co.uk	www.crucial.com	www.pcnextday.co.uk	www.pcupgrader.com
Details	www.buffalotech.co.uk	www.corsair.com	www.crucial.com	www.elixir-memory.com	www.kingston.com
REVIEW					
	Despite the evocative name, Buffalo RAM won't cause you to start grazing or headbutting people. In fact, it's no better than other kinds of memory. It's cheap, nothing much to look at and its latency timings are distinctly average. It is, however, good value. Having said that, the Corsair RAM is even cheaper and performs fractionally better.	Corsair is best known for making ludicrously overclockable RAM, but it also produces a range of far less expensive RAM known as Value Select. While we couldn't overclock this particular set of modules, it is the cheapest branded set of memory we could find. As a reliable, middle-of-the-road performer that will be readily available next time you upgrade, this is excellent value.	Crucial is the only memory manufacturer from which you can buy directly. Unfortunately this particular set of modules is still quite expensive. However, they run at slightly lower latency timings than most of the basic DDR memory, and so perform a little quicker. The Crucial was the cheapest basic DDR memory that would stably overclock from 400MHz to 440MHz, so if at some point you fancy dabbling in the world of overclocking, this module is a good choice.	This memory is about as generic as you can get. The latency timings are a standard 3-4-4-8 and, as you'd expect at this price, it won't overclock stably. Performance and reliability were fine, but we would still recommend spending £7 more on better-branded memory. That way, when it comes to upgrading again, you'll be able to find a matching set for your existing RAM.	Though rated for 3-3-3-8 timings, our review sample performed poorly at 3-5-5-11. We were sent replacement modules by Kingston. These performed properly (on a par with other 3-3-3-8 DDR memory), but despite having the same part number as the originals they had different chips – from Samsung. Consequently, we can't tell if the originals were faulty or just different. There's also no way for you to tell which you'll get.
					

DDR2



MANUFACTURER	BUFFALO	CORSAIR	MOT	OCZ
Model	D2U533B-1G	Value Select VS1GBKIT667D2	512MB x2	OCZ25331024ELDC6E-K
Type	DDR2	DDR2	DDR2	DDR2
Rating	★★★	★★★★★	★★★★	★★
Module size	512MB	512MB	512MB	512MB
Rated speed	533MHz	667MHz	533MHz	533MHz
Rated bandwidth	PC2-4200	PC2-5300	PC2-4200	PC2-4200
Latencies at this speed	4-4-4-12	5-5-5-7	4-4-4-12	3-3-3-8
Maximum speed in tests	Would not overclock	667MHz	Would not overclock	Would not overclock
Maximum processor speed in tests	Would not overclock	3.5GHz	Would not overclock	Would not overclock
Heatspreader	No	No	No	Yes
Price for pair (inc VAT)	£70	£81	£62	£113
Supplier	www.maplecomputercomponents.co.uk	www.scan.co.uk	www.pcnextday.co.uk	www.pc-memory-upgrade.co.uk
Details	www.buffalotech.co.uk	www.corsair.com	www.pcnextday.co.uk	www.ocztechnology.com
REVIEW				
	These Buffalo modules are almost identical to MOT's, apart from the price. They are rated to run at 533MHz with unremarkable 4-4-4-12 latency timings. They performed reasonably well in our benchmarks, but aren't worth getting excited about. At £69 they are reasonable value, though for £7 less you could buy the equivalent MOT modules.	Unusually, this Corsair Value Select is rated to run at up to 667MHz, considerably faster than the three other DDR2 modules that are rated at 533MHz. However, in case your motherboard BIOS does not support 667MHz memory, we also tested it at 533MHz. At this speed it proved to be the fastest DDR2 memory, while at 667MHz it left the rest far behind. Its benchmark scores at 667MHz were 142 in the video test, 117 in the image test and 80.6fps in Doom 3.	This little-known brand of memory is supplied by PC Nextday. The modules are cheap and have standard specifications. Unlike the other DDR2 RAM on test, the MOT is not sold as a matched pair, so when you buy two individual modules there's no guarantee that they'll work in dual-channel mode, but they should do. That said, performance is fine and the price is certainly competitive.	OCZ rates this set of modules to run at 533MHz, but at much lower latency timings than any of the other basic DDR2 RAM. Unfortunately for OCZ, these 3-3-3-8 timings don't appear to provide any real benefit as the higher timed Corsair (5-5-5-7) actually proved slightly faster in our benchmarks. The OCZ is also more expensive than its competitors, and as it's no faster we can't recommend it.
				



MOT	OCZ	PATRIOT
512MB x2	OCZ4001024WV3DC-K	PDC1G3200LLK
DDR	DDR	DDR
★★★★	★	★★★★
512MB	512MB	512MB
400MHz	400MHz	400MHz
PC3200	PC3200	PC3200
3-4-4-8	2.5-4-4-8	2-3-2-5
Would not overclock	440MHz	440MHz
Would not overclock	1.98GHz	1.98GHz
No	No	Yes
£80	£111	£101
www.pcnextday.co.uk	www.pc-memory-upgrade.co.uk	www.pc-memory-upgrade.co.uk
www.pcnextday.co.uk	www.ocztechnology.com	www.patriotmem.com
For such an obscure brand, this MOT memory is very expensive. At just over £80 you'd expect it to have slightly lower latency timings or some other smart feature, but the MOT is decidedly uninspiring. It consistently performed third from last in all the benchmark tests we ran. Windows corrupted when we tried to overclock it from 400MHz to 440MHz. We can't see anything that makes this set of modules stand out.	OCZ appears to have completely missed the point of basic DDR memory with this set of modules. It is not only the most expensive by nearly £40, but it doesn't have the lowest latency timings either. It is not an outstanding performer. Its only redeeming feature is that it can be overclocked, but even then it's still extremely poor value. Unless you're rich and stupid, this is best avoided.	The Patriot has the lowest latency timings of any of the DDR memory, and so performed the fastest in all the benchmarks. The biggest performance difference was in Doom 3, which ran 3.2fps faster with the Patriot than the Kingston. However, this performance comes at a hefty price. The Patriot is £25 more expensive than most of the other basic DDR modules, which is money that could be better spent on upgrading another component in your PC.
		

LABS VERDICT

MEMORY

Despite the hype from memory manufacturers about low-latency memory, lower timings don't make a big difference to performance. For greater performance, buy more memory or overclocking memory. Tests also revealed that fancy heatspreaders don't improve performance, even when overclocking. All they do is help protect the delicate memory chips from being damaged by grubby fingers.

We highlighted one set of RAM from each of the four categories as the best value. The winners in every category are from Corsair. For standard DDR and DDR2 RAM, you should buy the cheapest branded modules you can find. Consequently the VS1GBKIT400C3 and VS1GBKIT667D2 are our Best Buys for DDR and DDR2 respectively.

Some standard DDR and DDR2 RAM did overclock, but if you're serious about overclocking you need to pay a bit more. If you have a processor, motherboard and cooling system that can handle the strain, the two sets of Corsair modules we tested are ideal. The TWINX1024-4400C25PT offers extreme DDR overclocking at a reasonable £149, and it wins our Best Buy award. The DDR2 TWIN2X1024-8000UL, which can run up to 1GHz, costs £196. It wins our Most Desirable award. 

DDR RAM	DDR2 RAM
CORSAIR VS1GBKIT400C3	CORSAIR VS1GBKIT667D2
OVERCLOCKING DDR RAM	OVERCLOCKING DDR2 RAM
CORSAIR TWINX1024-4400C25PT	CORSAIR TWIN2X1024-8000UL

Overclocking DDR

CORSAIR	CRUCIAL	OCZ	CORSAIR	KINGSTON
TWINX1024-4400C25PT	BL2KIT6464L505	5001024ELDCGER2-K	TWIN2X1024-8000UL	KHX5400D2K2/1G
Overclocking DDR	Overclocking DDR	Overclocking DDR	Overclocking DDR2	Overclocking DDR2
★★★★★	★★★★	★★	★★★★★	★★★★
512MB	512MB	512MB	512MB	512MB
550MHz	500MHz	500MHz	1GHz	675MHz
PC4400	PC4000	PC4000	PC2-8000	PC2-5400
2.5-4-4-8	2.5-4-4-8	2.5-3-3-8	5-4-4-9	4-4-4-10
550MHz	500MHz	500MHz	1GHz	675MHz
2.47GHz	2.25GHz	2.25GHz	4.2GHz	3.54GHz
Yes	Yes	Yes	Yes	Yes
£149	£119	£139	£196	£236
www.scan.co.uk	www.crucial.com	www.pc-memory-upgrade.co.uk	www.scan.co.uk	www.pcupgrader.com
www.corsair.com	www.crucial.com	www.ocztechnology.com	www.corsair.com	www.kingston.com
Corsair RAM is a very popular choice among overclockers and it's not hard to see why. These particular modules are rated to run at 550MHz, the fastest DDR we've ever tested. The Corsair also benefits from low latency timings and is covered by a set of shiny silver heatspreaders that help keep prying fingers away. It might appear to be expensive for 1GB of RAM, but when it's this overclockable it's a price worth paying.	These modules belong to the Ballistix Tracer family of overclocker-friendly memory. They have a set of eight red and green LEDs that flash along the top edge depending on how much of the memory is being used. In addition, there's a line of blue glowing LEDs along the bottom of each module. Don't worry if this sounds garish; you won't be able to see the LEDs when your case is closed. This Crucial memory performed perfectly up to its 500MHz rated speed.	OCZ rates these modules to run at up to 500MHz, and that's exactly what they did. The OCZ has slightly lower latency timings than the Crucial and so is slightly faster, though you'd be hard pressed to notice the difference. But at only £10 less than the Corsair option, it would seem pointless to limit your overclocking adventures by buying the OCZ modules, even if they do have rather funky, gold-coloured heatspreaders.	If you're planning to overclock your Pentium 4 then a pair of these awesome Corsair modules should definitely be at the top of your shopping list. They are rated to run at up to 1GHz, so if you're lucky enough to have a motherboard, processor and cooling system that can cope with this extreme frequency, your PC will scream through any task you like. Just don't forget to buckle your seatbelt before you turn on your PC.	These Kingston modules performed well in our Pentium 4 test bed. They are rated to run up to 675MHz with latency timings of 4-4-4-10. The only problem is that they cost a whopping £236. Even if your processor and motherboard can't take full advantage of the ludicrously overclockable Corsair set of modules, you may as well buy it anyway and save £40.
				